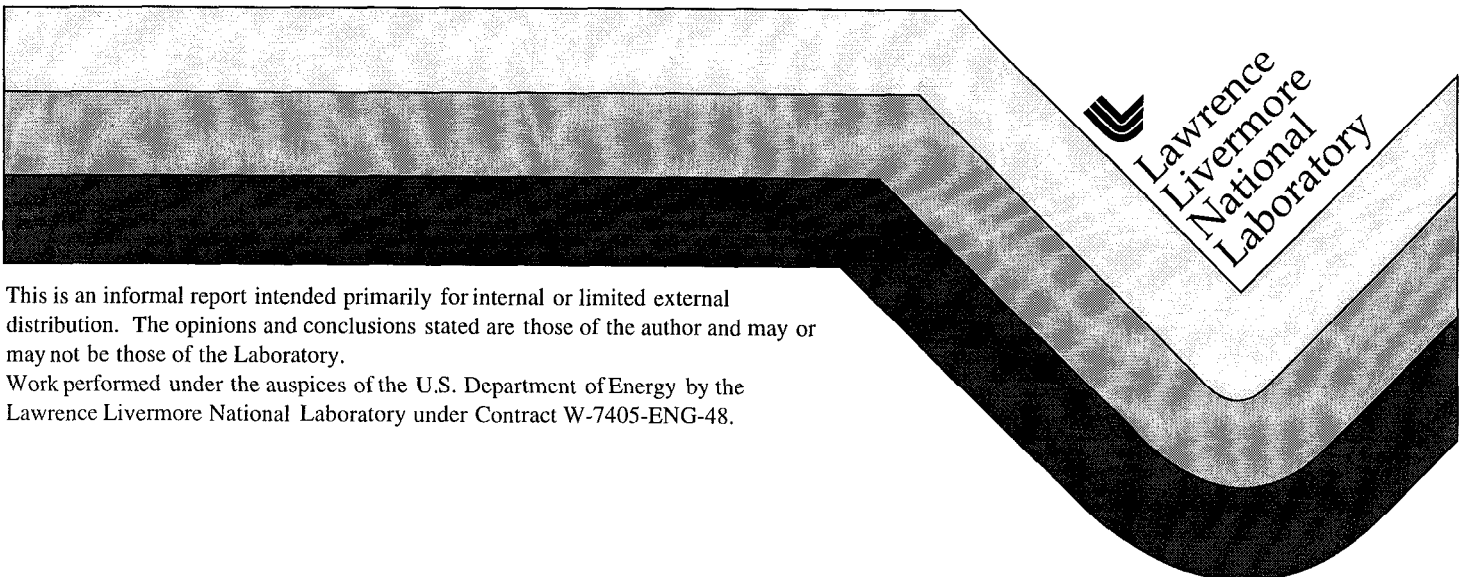


Characterization of Russian ballistic furnace shells, February, 1999, batch

Evelyn Fearon

April 2, 1999



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Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

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To: Distribution
From: Evelyn Fearon
Subject: Characterization of Russian ballistic furnace shells,
February, 1999, batch

This report documents the characterization of the latest batch of shells produced in the Ballistic Furnace System at the Lebedev Physical Institute, Moscow, Russia, that we received in mid-February, 1999. Assigned the batch number of LSC014, it consisted of three cassettes labeled 14, 15, and 16, containing 36 shells in each cassette. A group of 12 of the largest shells were selected for characterization that ranged in diameter from 1990 to 1830 μm . Two shells, 1988 and 2021 μm in diameter, were too fragile and did not survive initial handling.

We used the same characterization techniques as outlined in a previous report (TAT 99-003.2), doing an initial sphericity measurement on RACI, weighing each shell and then selecting shells that are spherical enough to run on the Sphere Mapper AFM.

The shells in cassettes 14 and 15 were the cleanest batch we have examined. There were no polymer shards stuck to the outside of the shells. There were a few very small black particles scattered on the outside of some, an occasional large black particle. We did see some swirls in the shell wall again, unlike the shells in LSC012. Figure 1 is an example of one such shell, number 14.26. The three shells selected from cassette 16, however, were all covered with fine white particles as viewed with a stereo zoom microscope. They were large enough and plentiful enough that I was unable to sphere map the shells. Figure 2 is a photograph of one such shell, taken while doing the RACI measurements. The shell is illuminated from below, so the particles show up as black speckles in the picture. The dark ring inside the shell is the image of the brass ring used in mounting the shell on the RACI microscope.

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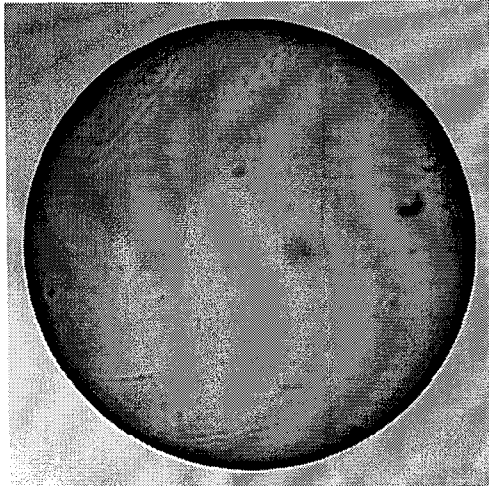


Figure 1. Photo of shell 14.26 illustrating swirls in the shell wall.

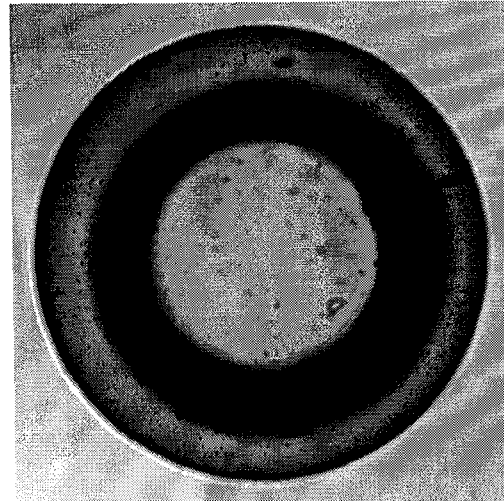


Figure 2. Photo of shell 16.12 showing large particles scattered over all of the shell. The dark ring in the center is the image of the brass ring used to mount shells in the RACI microscope.

RACI results show that the overall sphericity in this batch is not as good as some previous batches. The maximum *radius* out-of-round (ROOR) varied from 2.0 to 6.9 μm , with an average of 3.7 μm ROOR for the 12 shells measured. The maximum radius out-of-round should be less than 3 μm for the shell to be run on the Sphere Mapper. LSC014 had only 5 out of 12, or 40%, in that range of sphericity, compared to 22 out of 27, or 80%, for batch LSC012. One of the five in LSC014 was from cassette 16 and had the surface debris on it. The presence of the debris is evident in the RACI traces, when compared to one of the clean shells from the other cassettes. Figure 3 illustrates the difference in RACI traces.

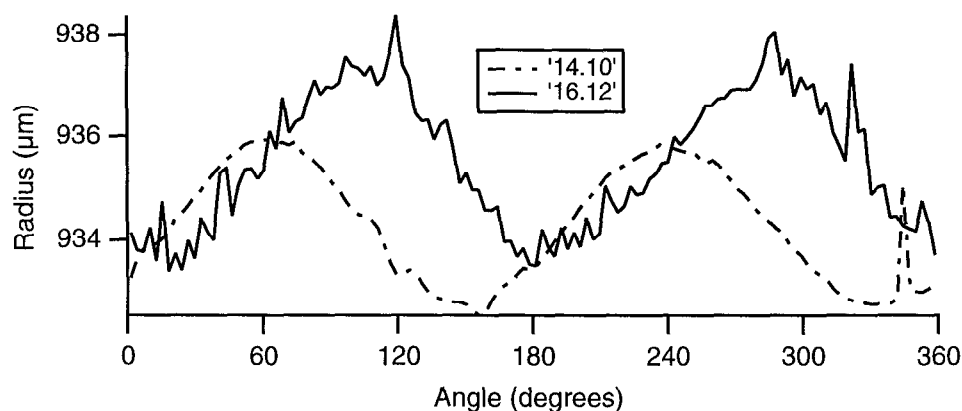


Figure 3. The presence of the large particles on the shells from cassette 16 were clearly visible in the RACI tracings. A shell from cassette 14 is shown for comparison.

I was able to Sphere Map four of the five shells selected from RACI data to be spherical enough. The large spikes due to the debris on shell 16.13 caused large hops in the AFM trace or to exceed maximum retraction, so I was unable to acquire complete data for that shell. The ROORs ranged from 0.6 to 4.2 μm for the four shells. All of the shells exhibited some middle mode bumps that are in the range of 0.5 to 2.5 μm tall by 100s of μm long. Figure 4 illustrates one of the most dramatic examples of this feature. All of the Sphere Mapper results are appended to the end of this report.

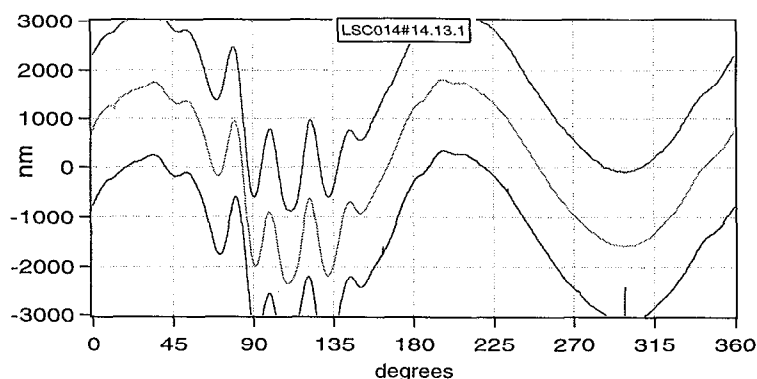


Figure 4. An example of some of the middle mode bumps of 1 to 2 μm high by 100s of μm wide seen on the Sphere Mapper of shells from this batch.

The set of 12 shells were all weighed and the wall thickness was calculated. The wall thickness varied from 8.8 to 6 μm . As can be seen from the chart in Figure 5, there is a trend to thinner walls for larger diameter shells.

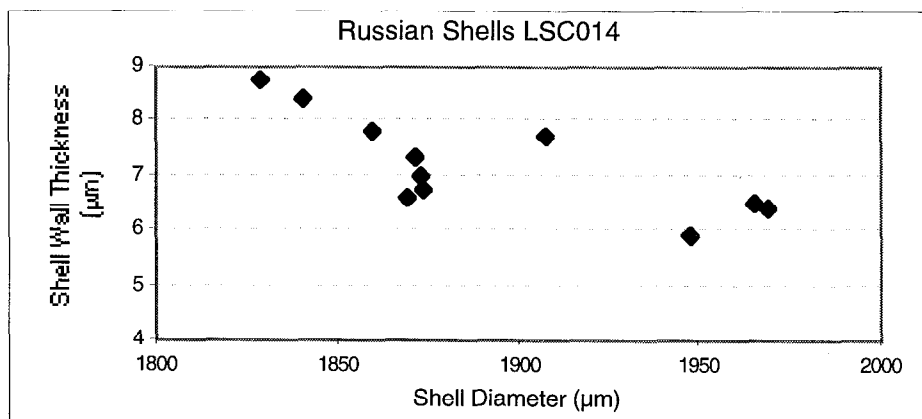
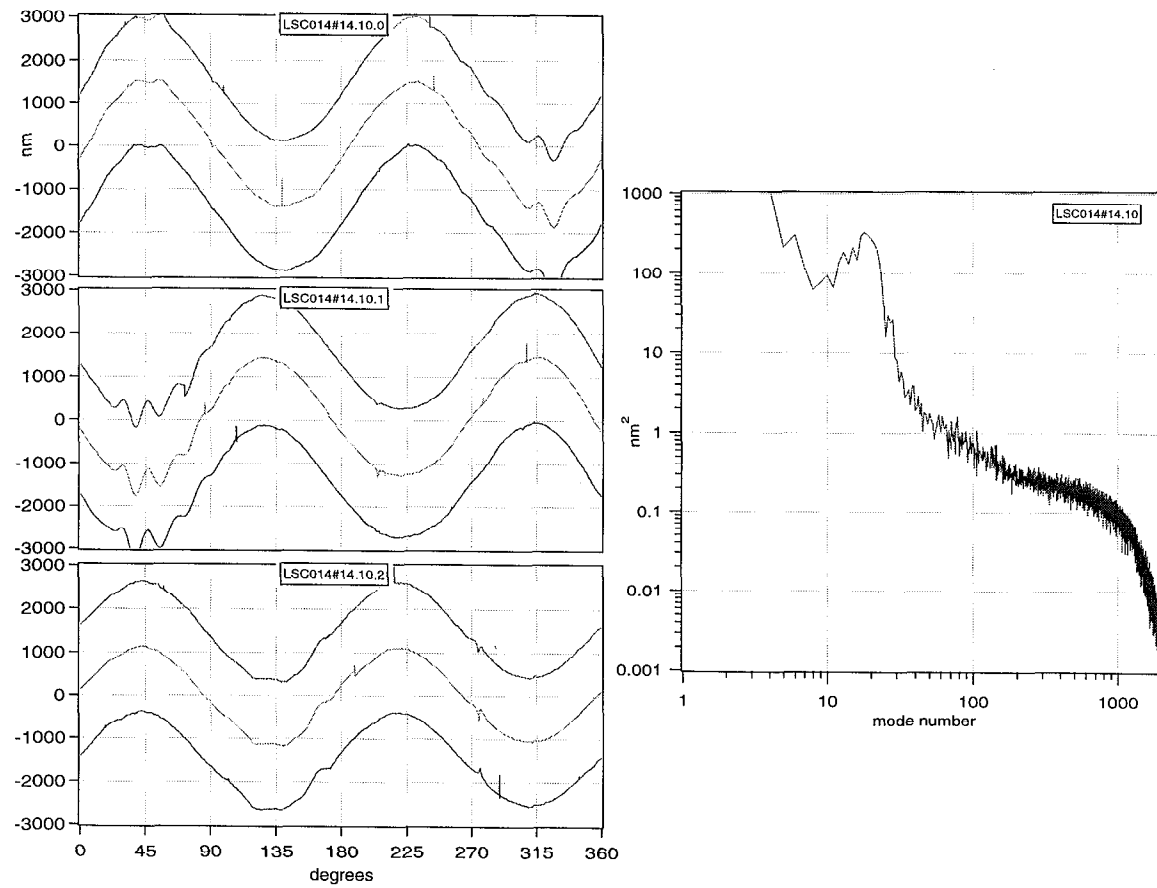
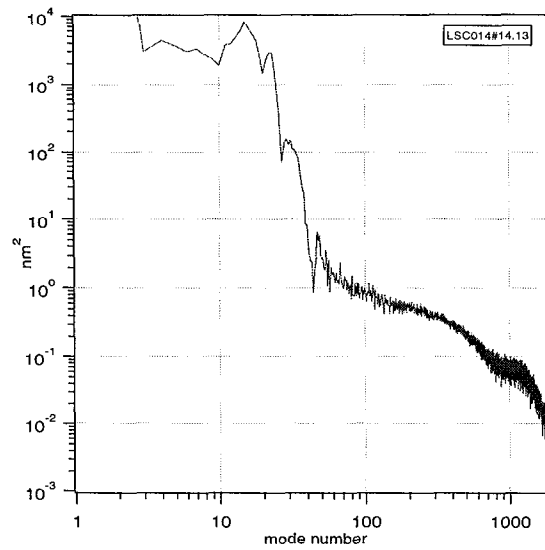
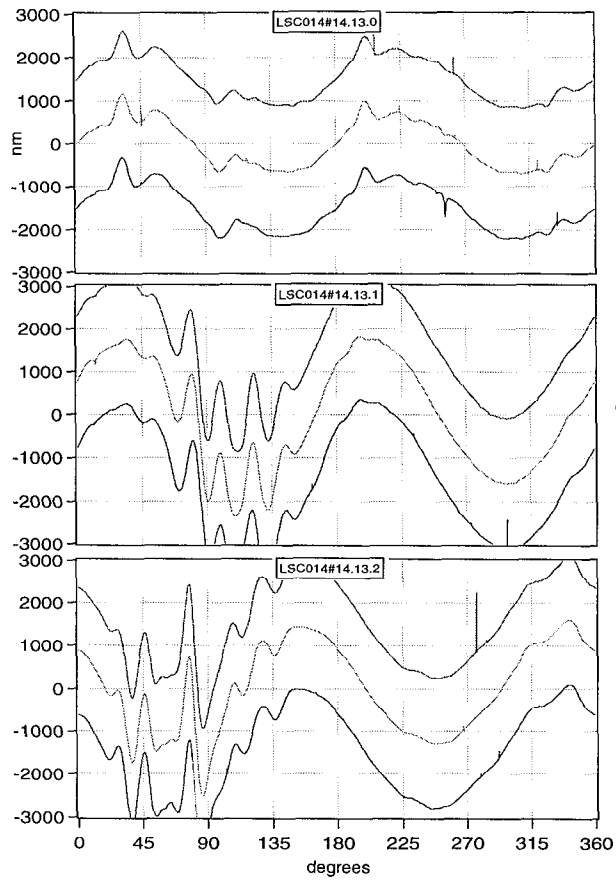


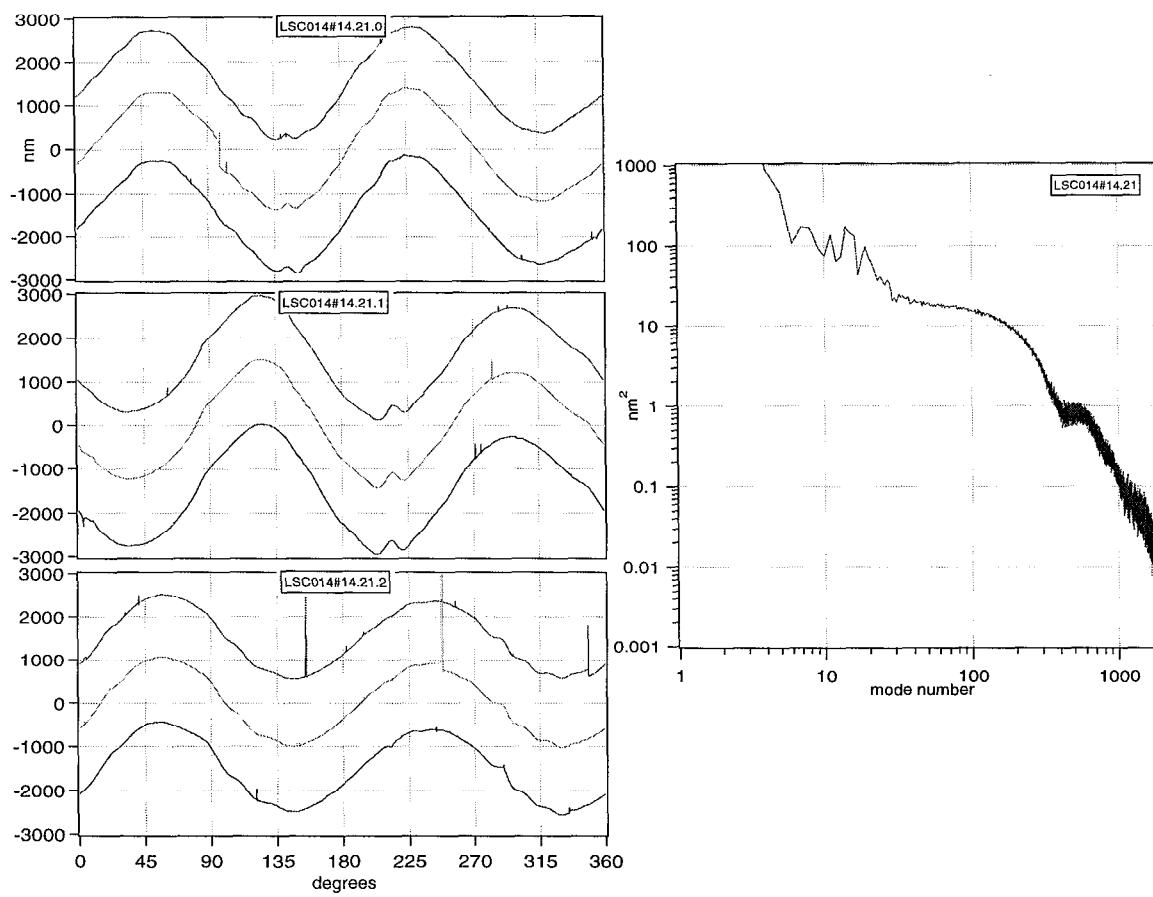
Figure 5. There is a slight decrease in shell wall thickness with increasing diameter.

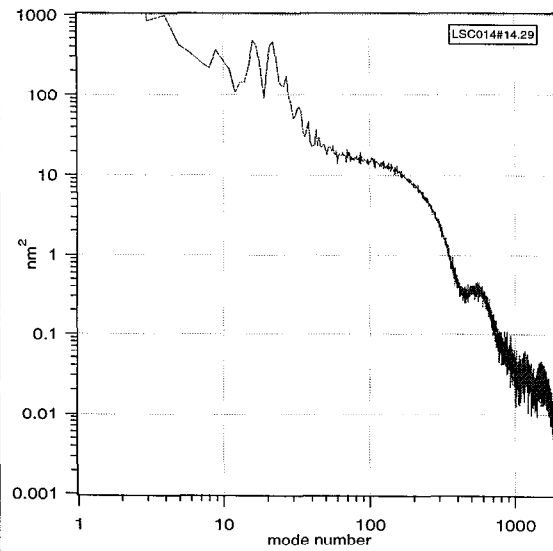
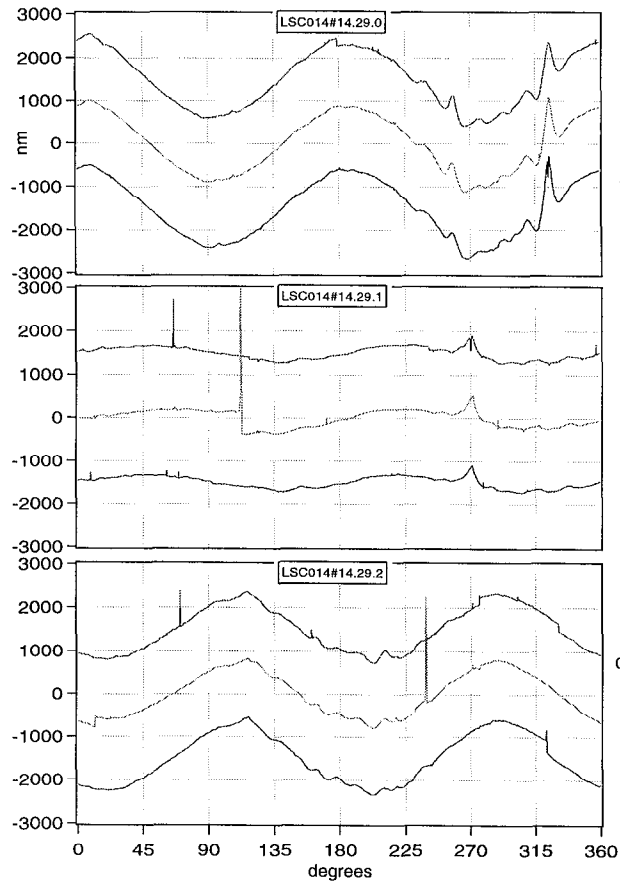
The complete table of characterization for this batch of shells is appended to this report.

Appendix Complete Sphere Mapper results









Appendix Complete tabulation of characterization

2/19/99		Russian Ballistic Furnace Polystyrene Shells					RACI boundary method							Polystyrene			
LSC014													Density:	1.05			
Number	Pressure (atm)	Temp (°C)	Init granule dia (mm)	Nom. shell dia (µm)	Notes	axis	Avg. radius (µm)	Mode 2 ampllt (µm)	Avg. dia (µm)	Avg. xyz dia (µm)	Radius OOR (µm)	MAX Radius OOR (µm)	mass (mg)	Calc. Wall (µm)	Sphere Map	Sphere Map ROOR (µm)	
14.10	0.084	862	0.67-0.7	1874	clean, a few small black particles on outside	x	934.2	1.49	1868.4	1869.2	2.98	3.04	0.0758	6.6	yes	2.9	
						y	935.3	0.61	1870.6		1.22					3.3	
						z	934.3	1.52	1868.6		3.04					2.4	
14.13	0.084	862	0.67-0.7	1972	some small black particles stuck on outside	x	983.9	1.18	1967.8	1969.2	2.36	2.36	0.0816	6.4	yes	1.7	
						y	985.3	0.5	1970.6		1					4.2	
						z	984.6	1	1969.2		2					4.1	
14.21	0.084	862	0.67-0.7	1883	clean!	x	936.5	1.7	1873	1874.07	3.4	3.4	0.0777	6.8	yes	2.9	
						y	937.3	1.2	1874.6		2.4					3.0	
						z	937.3	1.23	1874.6		2.46					1.9	
14.22	0.84	862	0.67-0.7	1971	swirls in shell wall; 1 small black particle, clean else	x	982.5	2.1	1965	1965.07		4.04	0.0824	6.5			
						y	982.2	2.02	1964.4		4.04						
						z	982.9	1.63	1965.8		3.26						
14.26	0.084	862	0.67-0.7	1886	swirls; 1 sm black particle, 1 larger black speck	x	936.6	2.07	1873.2	1873.13	4.14	4.14	0.0802	7.0			
						y	936.4	1.31	1872.8		2.62						
						z	936.7	1.63	1873.4		3.26						
14.29	0.071	851	0.67-0.7	1955	1 larger black particle stuck on outside	x	973.6	0.87	1947.2	1947.27	1.74	2.02	0.0737	5.9	yes	2.0	
						y	973.8	0.88	1947.6		1.76					0.6	
						z	973.5	1.01	1947		2.02					1.7	
14.32	0.071	851	0.67-0.7	1916	a few small black particles on outside	x	953.8	1.83	1907.6	1907.6	3.66	3.66	0.0923	7.7			
						y	953.7	0.59	1907.4		1.18						
						z	953.9	0.59	1907.8		1.18						
15.14	0.078	839	0.67-0.7	1988	broken in cassette												
15.21	0.078	839	0.67-0.7	2021	clean!	x	1008.2	2.1	2016.4	2016.7	4.2	4.2	broke it trying to SphereMap				
						y	1008.5	1.91	2017		3.82						
						z											
15.27	0.078	839	0.67-0.7	1858	several small black specks on outside	x	929.1	1.97	1858.2	1859.73		6.86	0.0884	7.8			
						y	930.8	3.43	1861.6		6.86						
						z	929.7	2.93	1859.4		5.86						
16.12	0.084	835	0.67-0.7	1876	surface uniformly covered with fine white particles	x	935.5	1.76	1871	1871.27	3.52	3.52	0.0843	7.4			
						y	935.7	0.9	1871.4		1.8						
						z	935.7	1.06	1871.4		2.12						
16.13	0.084	835	0.67-0.7	1838	fine white particles all over, fewer than #12	x	920.4	0.84	1840.8	1840.27	1.68	2.5	0.0929	8.4	too bumpy to map		
						y	920.5	0.2	1841		0.4						
						z	919.5	1.25	1839		2.5						
16.21	0.102	827	0.67-0.7	1834	fine white particles scattered uniformly over surface	x	915	2.18	1830	1828.8	4.36	4.36	0.0957	8.8			
						y	914	1.57	1828		3.14						
						z	914.2	1.68	1828.4		3.36						